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The Use of Wood Fiber for Reducing Risks of Hydrophobicity in Peat-Based Substrates

Stan Durand [1], Brian E. Jackson [2], William C. Fonteno [2] and Jean-Charles Michel [1,*]

[1] EPHor, L'Institut Agro, 49045 Angers, France; stan.durand@agrocampus-ouest.fr
[2] Department of Horticultural Sciences, North Carolina State University, Raleigh, NC 27695, USA; brian_jackson@ncsu.edu (B.E.J.); wcf@ncsu.edu (W.C.F.)
* Correspondence: jean-charles.michel@agrocampus-ouest.fr

Abstract: Peat substrates are well known to become hydrophobic during desiccation, thus degrading their water retention properties. Synthetic wetting agents are commonly incorporated to limit the risk of hydrophobicity, but substrates companies are searching for more sustainable alternatives. To that end, the effect of wood fiber addition in peat-based mixes was measured using contact angles and hydration curves. The study was carried out on two raw materials (white milled peat and wood fiber) and binary mixes. The results showed a shift from hydrophilic to more hydrophobic character with a decrease in the ability to rewet of peat-based substrates in relation to the intensity of drying, whereas wood fiber remained hydrophilic. Increasing wood fiber content in peat-based mixes improved the rehydration efficiency, but with a lower intensity of that measured with synthetic wetting agent addition. Our results highlighted the hydrophilic nature of wood fiber and demonstrated an additional benefit of wood fiber use in peat-based growing media.

Keywords: peat; wood fiber; rewetting; wettability; water retention; physical properties

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1. Introduction

Peats are by far the most widely used components of horticultural substrates [1], mainly due to their physical properties. Their sources of supply are very important worldwide, with a not very prohibitive cost. However, its use is increasingly being discussed because peat is a fossil and non-renewable resource, and peatlands have a major environmental function of storing large quantities of carbon [2]. Although the use of peat by horticultural activities accounts for only 30% of its consumption and only 0.02% of the peatland area worldwide (800 km^2 for a total of about 4 million km^2), new European incentives are aimed at limiting the exploitation of wetlands and rehabilitation of peatlands after extraction [3,4].

Thus, substrate companies are seeking to reduce peat content in their recipes by incorporating more renewable organic materials with a lower carbon footprint, while maintaining or even improving the agronomic qualities of substrates. These mixes usually aim to increase the air-filled porosity (AFP) of peat-based growing media using peat substitutes with coarser porosity. More recently, emerging works are looking for organic alternatives to synthetic wetting agent used for reducing the risks of peat hydrophobicity occurring during its drying, by promoting mixes with both complementary and more hydrophilic peat alternatives.

Hydrophobicity is a major potential risk for many organic substrates, especially peat-based substrates [5]. Several sources can lead to a degradation of wettability and then water capture and water retention properties induced by the acquisition of hydrophobic properties. Michel et al. [6] showed a lower root development in some different substrates managed with a too restrictive irrigation. They also measured a large decrease in the ability to capture and to retain water in peat:bark mixes after open-air storage for few months. The change from hydrophilic to hydrophobic character during drying of peats and barks has been demonstrated from contact angle measurements [7]. This decrease in wettability was also observed by Fields et al. [8] and Michel et al. [6,9], on the basis of hydration curves for a large majority of substrates depending on their moisture content. In most cases, the drier a substrate, the more it exhibits hydrophobicity, leading to increase difficulty to rewet and to recover its initial retention properties. Considering data in the literature obtained from both contact angle measurements and hydration efficiency tests, a classification of the wettability of materials was established by Michel [5]: black peat < bark < white peat < wood-based products < coir.

The market for wood fiber as a substrate component has been expanding worldwide for about ten years, although its industrial development started in the 1970's [10]. Wood fibers can be distinguished according to the tree species used, mainly conifers (*Pinus*, *Abies* and *Picea*), due to their lower phytotoxic molecule content compared to hardwood species [11], and the defibration (twin-disc refiner, extruder, hammer-mill) processes. This interest in for wood fiber is due to its wide availability around the world, its renewability and reduced carbon footprint compared to peat or other materials, as well as its low production cost. Literature on the physical properties of some wood fibers reports low water holding capacity around 0.25–0.35 v/v, air-filled porosity varying from 0.5 to 0.7 v/v, and water buffering capacity close to 0, therefore wood fiber is mainly used in mixes for its aeration properties [12,13]. Additionally, Jackson [14] reported a higher root growth due to an increase in air content induced by wood fiber addition in peat-based substrates.

The objective of our work was to study the rehydration properties of wood fiber and its influence on mixes with peat in different proportions. This work also aimed to quantify the influence of the initial water content (i.e., the intensity of desiccation) on the rewetting properties of raw materials and mixes.

2. Materials and Methods

2.1. Materials

Experiments were carried out on two raw materials: a white milled peat (P) (0–25 mm, H3-H5 Von Post index, 0.11 g/cm^3 bulk density) extracted in Lithuania, and a wood fiber (WF) (0–4 mm, 0.08 g/cm^3 bulk density). This wood fiber results from a process of defibration by passing conifer wood chips through a retruder. Three binary peat:wood fiber (P:WF) mixes with different proportions (80:20, 60:40, 40:60 vol.) were also studied. No fertilizer or wetting agent were added in order to avoid their potential effects on the rehydration properties. However, peat with wetting agent addition was tested in order to compare its ability to rewet with those of raw materials and peat:wood fiber mixes. The wetting agent was added with the recommended concentration of 250 mL per m^3 of peat for 40% initial moisture content (MC) and 200 mL wetting agent wetting agent per m^3 of peat for 50% and 60% MC.

2.2. Experimental Procedure

2.2.1. Water Retention Properties

Water retention curves were established using the standard reference method NF EN 13041 [15], for which bulk density (BD), total porosity (TP), air-filled porosity (AFP), water holding capacity (WHC) and available water (AW) were calculated. The principle consists in putting substrate–filled cylinders into equilibrium at different and successive water potentials using a suction table, i.e., −1 kPa; −3.2 kPa; −5 kPa and −10 kPa, and to determine their volumetric water content at these values of water potentials. Six replicates were carried out for each substrate.

2.2.2. Wettability Measurements: Two Complementary Approaches

Preparation of the Materials

Both contact angle measurements and hydration efficiency tests were performed on samples previously equilibrated at three different initial MC expressed in weight of 40%, 50%, and 60% w/w. The thresholds for initial MC were defined from results previously obtained by Fields et al. [8] and Michel et al. [6,9]: 40% *w*/*w* corresponding to a lower limit where peats become hydrophobic with a very low ability to rewet, and, conversely, 60% *w*/*w* representing a MC for which all materials are hydrophilic. The MC of each sample were checked on four replicates prior to both experiments using the Ohaus MB45 Moisture Analyzer (Ohaus, Nänikon, Switzerland). The MC was expressed by weight for the preparation of the samples because it allows comparisons among materials and does not depend on BD, which can largely vary depending on the materials and its degree of compaction.

Contact Angle Measurements

Contact angles were measured from the capillary rise method described by Michel et al. [7]. The method consisted of following the capillary rise of different liquids (n-hexane, then water) on ~5 cm^3 column of substrates by using the Krüss Processor Tensiometer K12® (Krüss GmbH, Hamburg, Germany). The speed of capillary rise, translated by the increase in weight of the column, is measured in relation to time by the computer, and the contact angle was determined from the following Washburn's equation [16]:

$$cos\,\theta = \frac{m^2}{t}\frac{\eta}{\rho^2\sigma c} \tag{1}$$

where: t is the time (s); m is the mass of adsorbed liquid (g); η, ρ, σ the viscosity (mPa), ρ the density (g/cm^3), σ the surface tension of the liquid (mJ/m^2), respectively; θ the solid/liquid contact angle and c corresponds to an empirical constant of the porosity and tortuosity of the capillaries, which depends on particle size and degree of packing. The parameter c was initially assessed by using a liquid with a very low surface tension (hexane) which completely wets the sample (θ = 0). The water/material contact angles were then calculated and the wettability estimated, knowing that the greater the contact angle, the more the hydrophilicity decreases or the hydrophobicity increases. However, when the material is too hydrophobic (contact angles greater than 90°), there is no capillary rise, and the degree of hydrophobicity can then not be estimated by capillary rise method. Contact angle measurements were carried out on four replicates per liquid (hexane then water) for a given MC and for each substrate tested.

Hydration Curves

Wettability was also assessed by a macro-scale method using hydration curves, adapted from the method detailed by Fields et al. [8] and Schulker et al. [17]. This method consists in measuring the water uptake of a 200 cm^3 substrate column during successive drip irrigations. A 200 cm^3 substrate sample was homogeneously packed in a 10 cm height cylinder, with the objective of having the same BD (given in Table 1) for the same material whatever the MC, then placed in the hydration efficiency unit. That implied a higher compaction of substrate in the cylinder used for the hydration curves compared to those used for water retention curves, in order to avoid any change (i.e., compaction) in volume during rehydration (observed for some materials when maintaining the bulk density determined from the NF EN 13041 [15] standard procedure).

The substrate column was then subjected to six successive hydration events which involved passing 200 mL water in approximately 5 min through each sample and to collect effluent as it came out the bottom from which cumulative water content (WC) retained (from WC_1 = water content after one hydration event to WC_6 = water content after six hydration events, *v*/*v*) in the substrate was calculated. After these six hydration events, the substrate column was saturated from the bottom over 15 min, then freely drained for 30 min in order to determine container capacity (CC, *v*/*v*) of each material. At least eight replicates per MC and per substrate were carried out.

For the analysis of results, the initial MC, expressed in weight (*w*/*w*) for the preparation of the materials was converted in volumetric water content (*v*/*v*). Table 1 contains the initial MC expressed in weight and the initial volumetric water content (WC_0) of the samples, and their dry bulk densities defined for hydration curves as well. Initial MC was shown in the hydration curves (Figures 1 and 2) for the *x*-axis value = 0, i.e., for Hydration Event = 0. For example, MC = 40%, 50% and 60% w/w represented WC_0 = 0.08, 0.12 and 0.19 v/v for peat; 0.07, 0.10 and 0.15 v/v for wood fiber, respectively. Curves connecting all points with the same symbol (7 points in total) corresponded to the cumulative water capture after each successive irrigation event (i.e., a total of six 5-min events). The straight horizontal lines (without symbols) corresponded to container capacity values (CC, v/v).

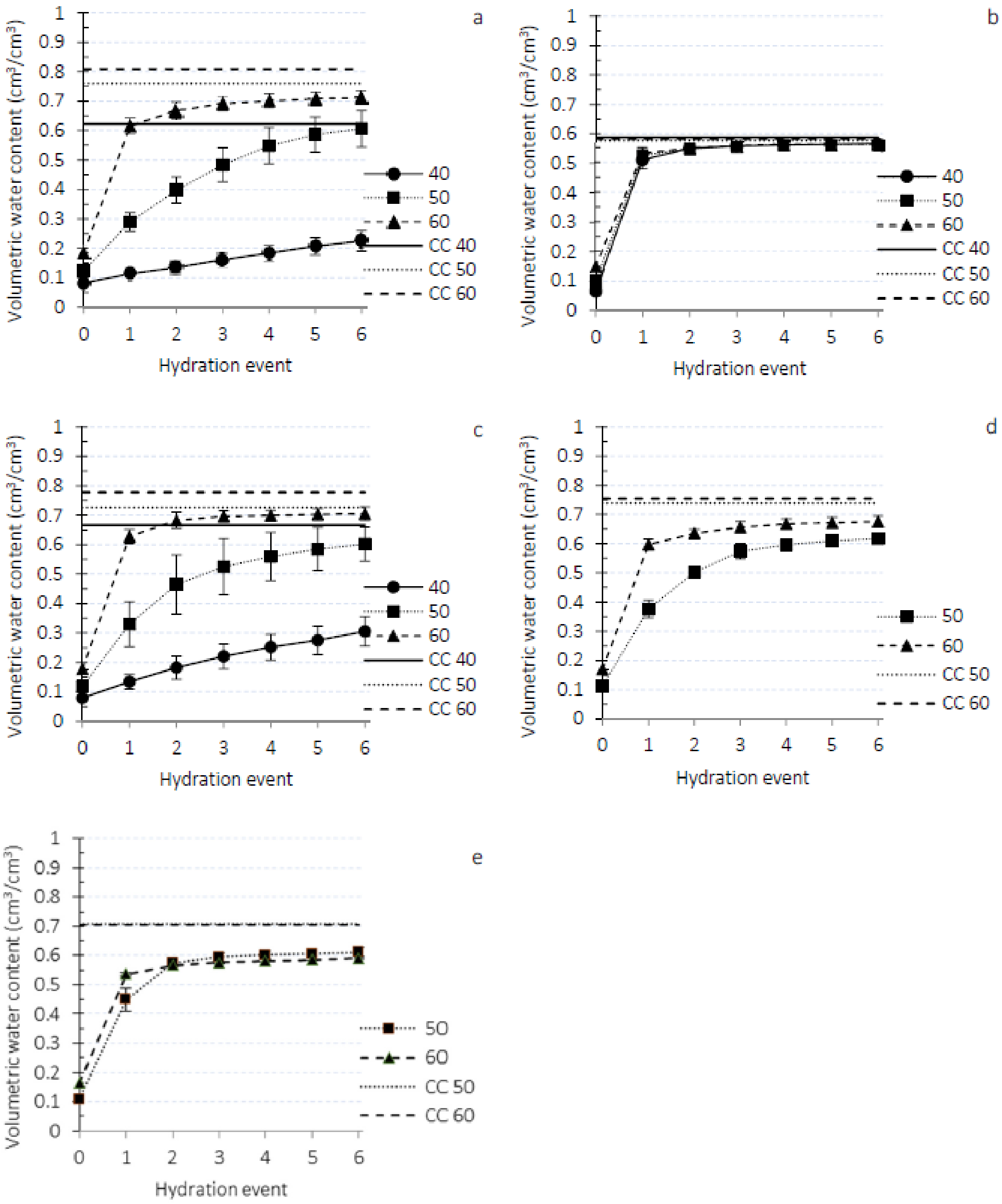

Figure 1. Cumulated water capture during six successive irrigation events and container capacity (CCMC) for peat (**a**), wood fiber (**b**) and 80:20 (**c**), 60:40 (**d**), 40:60 (**e**) peat:wood fiber mixes depending on initial moisture contents (MC = 40, 50, 60% w/w).

Table 1. Initial moisture contents expressed in weight and volumetric water contents for peat, wood fiber and mixes peat:wood fiber.

Substrates	Bulk Density ($g \cdot cm^{-3}$)	Initial Moisture Content in Weight (%) [a]		
		40%	50%	60%
		Initial Volumetric Water Content (%) for both Contact Angle Measurements and Hydration Curves [b]		
P [c]	0.13	0.08	0.12	0.19
80:20 [d] P:WF	0.12	0.08	0.12	0.18
60:40 [d] P:WF	0.12	0.08	0.11	0.17
40:60 [d] P:WF	0.11	0.07	0.11	0.16
WF [e]	0.10	0.07	0.10	0.15

[a] Initial moisture contents expressed in weight (% mass of water per mass of material). [b] Initial volumetric water content (WC_0) expressed in volume (% volume of water per volume of material. [c] Peat (P). [d] Percentage of peat (P) and wood fiber (WF) in the mix. [e] Wood fiber (WF).

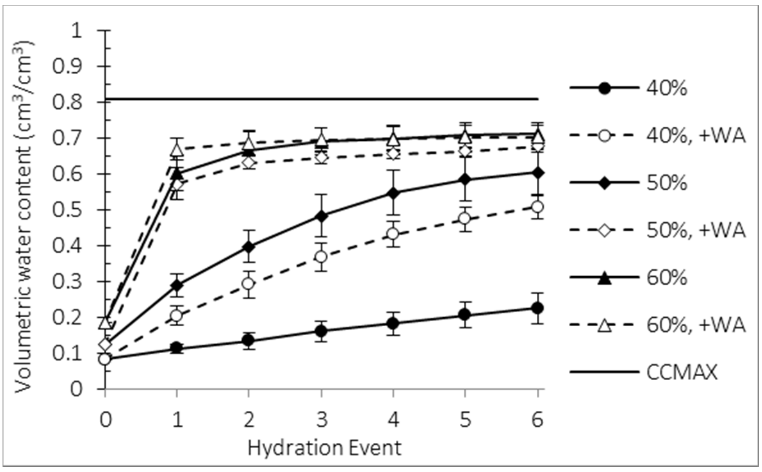

Figure 2. Hydration curves for peat with wetting agent (+WA) or without wetting agent according to initial moisture contents (40, 50, 60% *w*/*w*); CCMAX = Container Capacity at 60% *w*/*w* initial Moisture Content (*w*/*w*).

From the hydration curves, some notable points were identified:

- The water volumes retained (*v*/*v*) by the substrate column after 1 and 3 irrigations, «WC_1» and «WC_3», i.e., after 5-min and 15-min irrigation (5-min irrigation corresponding to a usual time of watering; and 15 min to a maximum);
- The container capacity (CC_X), corresponding to the maximum water content (*v*/*v*) recovered by the substrate initially equilibrated at initial MC of 40% (CC_{40}), 50% (CC_{50}), and 60% (CC_{60}) *w*/*w*;
- The maximum container capacity (CC_{MAX}), considered as the CC value (*v*/*v*) for a substrate prepared at the 60% *w*/*w* MC, i.e., when the substrate was fully hydrophilic and quickly rewetted.

The hydration curves were interpreted using calculations of key-parameters based on the CC_{MC}, CC_{MAX} and $WC_{X(MC)}$ (*v*/*v*) values obtained for a given material initially equilibrated at a given initial MC, where X corresponded to the number of irrigation events. The $WC_{1(MC)}/CC_{MAX}$, $WC_{3(MC)}/CC_{MAX}$ and CC_{MC}/CC_{MAX} ratios, which reflect the ability of a substrate to rewet after the 1st and 3rd irrigations and to recover its initial water retention properties, respectively, were calculated.

2.2.3. Statistical Analysis

The statistical analysis of the results was carried out using the R Studio Software (R version 3.5.2). The influence of both wood fiber proportion and initial MC on the wettability measurements and water retention properties were tested by one-way analysis of variance (one-way ANOVA, linear models), after checking for normality of datasets by Shapiro-Wilk tests ($p < 0.05$). Whenever significant differences were observed ($p < 0.05$), Tukey's range tests (Tukey-HSD) were applied to identify where differences occurred.

3. Results

3.1. Wettability Measurements

3.1.1. Contact Angles

Wood fiber exhibited contact angles lower than 90° for all tested MC (Table 2), and demonstrated hydrophilic characteristics, whatever the intensity of drying.

Table 2. Contact angles (°) measured on substrates prepared at 40%, 50% and 60% Moisture Contents, (90° = no capillary rise).

	MC = 40% [a]	**MC = 50%** [a]	**MC = 60%** [a]
P [b]	90.0° a [e] A [f]	90.0° a A	87.0° b A
80:20 [c] P:WF	90.0° a A	89.4° b B	86.9° c A
60:40 [c] P:WF	89.7° a B	88.5° b C	86.0° c B
40:60 [c] P:WF	89.5° a C	88.1° b D	85.7° c B
WF [d]	86.1° a D	85.8° ab E	85.5° b B

[a] Moisture contents (MC) expressed in weight (% mass of water per mass of material). [b] Peat (P). [c] Percentage of peat (P) and wood fiber (WF) in the mix. [d] Wood fiber (WF). [e] Statistical comparisons (Tukey, $p \leq 0.05$) within a row (lowercase letters) to compare moisture content effects for a given material. [f] Statistical comparisons (Tukey, $p \leq 0.05$) within a column (uppercase letter) to compare the materials for a given MC.

For peat and peat-based mixes, the contact angles are consistently equal to 90° for MC = 40% w/w, defining their hydrophobic character (in this case, there was no capillary rise. Conversely, mixes were somewhat hydrophilic (contact angles lower than 90°) for MC = 50% and moreover 60% w/w, whereas peat remained hydrophobic for 50% MC and was only hydrophilic at 60% MC. Thus, contact angles measured confirmed classification established by Michel [5], with peat presenting high risks of hydrophobicity, whereas wood fiber was hydrophilic. Accordingly, the more the wood fiber proportion in peat-based mixes, the smaller the contact angles, the more the wettability of mixes.

3.1.2. Hydration Curves

Raw Materials and Mixes

Wood fiber captured most of the total water retained with the first irrigation (WC_1/CC_{MAX} closed to 0.90 v/v), and the CC_{MC} values measured at the end of the experiments are also similar (0.58 v/v), whatever its initial MC (Figure 1). These results were reflected in contact angles measured (86.1° to 85.5°), confirming that wood fiber remained hydrophilic, whatever the intensity of drying (Table 2).

Peat demonstrated a different rewetting behavior than wood fiber. The water captures after one and three irrigation events (WC_1 and WC_3), as well as CC_{MC} values, decreased with the intensity of drying (Figure 1). WC_1 reached 0,60 v/v for an initial MC of 60% w/w, but only 0.11 v/v for MC = 40% w/w; CC values decreased from 0.81 v/v to 0.62 v/v for initial MC of 60% and 40% w/w, respectively. These results indicated an increase in the degree of hydrophobicity according to the intensity of drying process. Dynamics of water capture largely differed depending on the initial MC: water capture was very slow and progressive for the lowest MC (40% w/w), but conversely was progressively faster and quickly reached a plateau for the highest MC (60% w/w) with a value close to its maximum

CC measured. In addition, water preferential flows appeared on the outside of substrates columns for MC of 40% and 50% w/w.

The influence of wood fiber addition was assessed from Figures 1 and 2 and Table 3, where WC_1/CC_{MAX}, WC_3/CC_{MAX} and CC/CC_{MAX} ratios for raw materials and mixes were compared (only the 80:20 P:WF was tested for MC = 40% w/w). Under the driest condition (MC = 40% and 50% w/w) where peat was more hydrophobic, the wood fiber addition increased the ability to rewet of mixes. The more the wood fiber content in the mixes, the more water capture. For example, at MC = 50%, WC_1/CC_{MAX} reached 0.36, 0.42, 0.46, and 0.63 for peat-based substrates with 0%, 20%, 40%, 60% wood fiber (Table 3).

Table 3. Values of the WC_1/CCMAX, WC_3/CCMAX and CC/CCMAX ratios, depending on the initial moisture content.

	WC_1/CC_{MAX} [a]			WC_3/CC_{MAX} [b]			CC/CC_{MAX} [c]		
	MC = 40% [d]	MC = 50% [d]	MC = 60% [d]	MC = 40%	MC = 50%	MC = 60%	MC = 40%	MC = 50%	MC = 60%
P [e]	0.14 a [h] A [i]	0.36 b A	0.77 c A	0.20 a A	0.60 b A	0.85 c A	0.77 a A	0.94 b A	1 b A
80:20 [f] P:WF	0.17 a A	0.42 b AB	0.81 c A	0.28 a B	0.67 b AB	0.89 c AB	0.86 a B	0.95 ab A	1 b A
60:40 [f] P:WF	ND [j]	0.46 a B	0.80 b A	ND	0.76 a BC	0.88 b AB	ND	1 a A	1 a A
40:60 [f] P:WF	ND	0.63 a C	0.77 b A	ND	0.83 a C	0.85 a A	ND	1 a A	1 a A
WF [g]	0.88 a B	0.90 a D	0.91 a B	0.96 a C	0.96 a D	0.96 a B	1 a C	1 a A	1 a A

[a] ratio of water content in volume after one irrigation event (WC_1) to the maximal container capacity (CC_{Max}) of a given material. [b] ratio of water content in volume after three irrigation events (WC_3) to the maximal container capacity (CC_{Max}) of a given material. [c] ratio of water content in volume of the container capacity (CC) of a material to the maximal container capacity in volume of a given material. [d] Moisture contents (MC) expressed in weight (% mass of water per mass of material). [e] Peat (P). [f] Percentage of peat (P) and wood fiber (WF) in the mix. [g] Wood fiber (WF). [h] Statistical comparisons (Tukey, $p \leq 0.05$) within a row (lowercase letters) to compare moisture content effects on ratio WC_1/CC_{MAX}, WC_3/CC_{MAX} and CC/CC_{MAX} for a given material. [i] Statistical comparisons (Tukey, $p \leq 0.05$) within a column (uppercase letter) to compare the materials for a given MC. [j] Data not determined (ND).

On the other hand, in the wettest state (MC = 60% w/w, i.e., where all materials were hydrophilic), water capture was quite similar for raw materials and mixes; all being hydrophilic for this moisture content. Thus, the addition of wood fiber into peat-based mixes improved the rewetting capacity of mixes in low MC (MC $\leq$ 50%) when peat was more hydrophobic.

Effects of Wetting Agent Addition in Peat and Comparison with Peat:Wood Fiber Mixes

For lower MC (MC = 40% and 50% w/w), wetting agent addition in peat increased the water capture (Figure 2). For example, the water capture reached 0.50 v/v for peat with wetting agent but only 0.22 v/v for peat without agent at 40% w/w MC after six irrigation events. At 50% w/w MC, the water capture reached a plateau with a maximum value of 0.60–0.65 v/v from the second irrigation event for peat with wetting agent, whereas the water capture did not reach this plateau value after 6 irrigation events (Figure 2). Conversely, at 60% w/w MC, no additional effect of wetting agent was observed; peat being hydrophilic with or without wetting agent (Figure 2).

Despite wetting agent addition, container capacity CC did not reach the maximum container capacity CC_{MAX} for peat prepared at 40% and 50% MC (CC_{40} = 0.65 v/v; CC_{50} = 0.74 v/v). Despite the increase in water capture, wetting agent did not allow recovery to the maximum retention properties of peat when dried to both 40% and 50% MC.

Figure 3 compared the water capture of peat:wood fiber mixes to that of wetting agent incorporated in peat, all materials prepared at a 50% w/w MC. A similar water capture after 3 irrigation events was observed for peat with wetting agent and P:WF mixes (WC_3/CC_{MAX} close to 0.8 v/v), which were higher than that of peat without wetting agent (WC_3/CC_{MAX} = 0.6 v/v). However, wetting agent addition in peat allowed a higher water capture after the first irrigation event compared to peat:wood fiber mixes, and the plateau corresponding to the maximum water content was reached with the second irrigation. Wood fiber addition improved water capture depending on its proportion: the plateau was also reached from the second irrigation for the 40:60 peat:wood fiber mix (such as for peat with wetting agent), where four irrigation events were needed for the 60:40 peat:wood fiber mix.

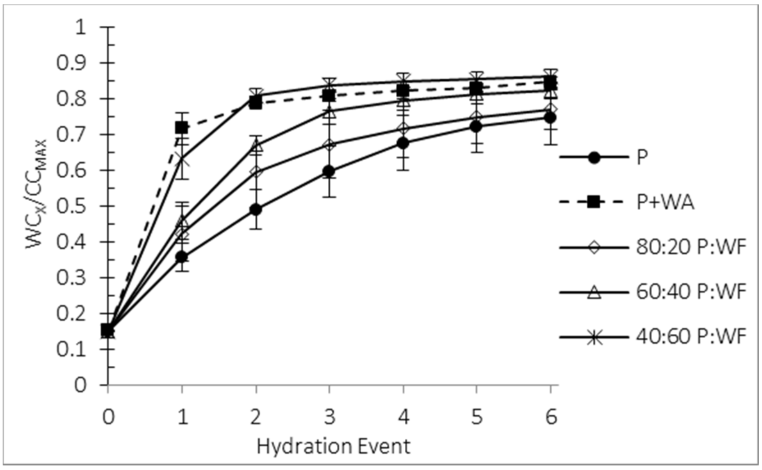

Figure 3. Cumulated water capture for comparing effects of both wetting agent incorporated in peat and wood fiber addition in peat-based mixes for materials initially prepared at 50% w/w initial moisture content.

From these observations, the addition of 60% vol. wood fiber in peat was needed to obtain similar ability to rewet to wetting agent incorporated in peat.

3.2. Water Retention Properties

Figure 4 represented water retention curves fitted using the Van Genuchten [18] model from data obtained by suction table, and Table 4 summarizes the main physical characteristics. All materials exhibited a high total porosity (0.93–0.95 v/v), in agreement with the literature [19,20]. Peat presented high water retention properties, but its air-filled porosity was consequently low, according to the 0.20 v/v minimum threshold defined by De Boodt and Verdonck [21]. Conversely, wood fiber showed a high AFP, but its WHC and AW are very low, and water release mainly occurred between −1 kPa and −3 kPa. Wood fiber addition in peat-based substrates led to decreases in water retention, but inversely to increases in AFP.

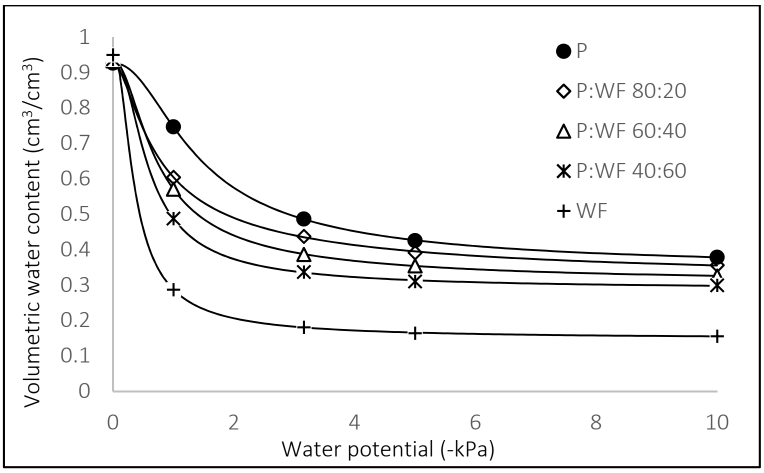

Figure 4. Water retention curves fitted according to the Van Genuchten [18] model from data obtained by suction table for peat (P), wood fiber (WF) and peat:wood fiber mixes (P:WF).

Table 4. Main physical properties calculated for peat, wood fiber and mixes peat:wood fiber from water retention curves.

	Bulk Density (BD) [a]	Total Porosity (TP) [b]	Air-Filled Porosity (AFP) [b]	Water Holding Capacity (WHC) [b]	Available Water (AW) [b]
P [c]	0.12 a [f]	0.93 a	0.18 a	0.75 a	0.37 a
80:20 [d] P:WF	0.11 ab	0.93 ab	0.33 b	0.60 b	0.25 b
60:40 [d] P:WF	0.11 b	0.93 b	0.36 c	0.57 c	0.24 b
40:60 [d] P:WF	0.10 c	0.94 c	0.45 d	0.49 d	0.19 c
WF [e]	0.08 d	0.95 d	0.66 e	0.29 e	0.13 d

[a] Values expressed in g/cm^3. [b] Values expressed in percentage of the total volume (v/v). [c] Peat (P). [d] Percentage of peat (P) and wood fiber (WF) in the mix. [e] Wood fiber (WF). [f] Statistical comparisons (Tukey, $p \leq 0.05$) within a column to compare the materials for a given physical property.

4. Discussion

4.1. Validity and Robustness of Methods and Results

The observed behavior regarding wettability and water capture are consistent between both contact angle measurements and hydration curves. Both methods confirmed that the wood fiber remained hydrophilic, whatever the intensity of drying (at least down to 40% w/w initial MC). Conversely, the evolution from a hydrophilic to a hydrophobic character of peat during drying was also demonstrated by the both methods, confirming conclusions presented by Michel et al. [7], Fields et al. [8] and Michel [5].

Hydration efficiency tests were carried out on materials with higher compaction than that defined in NF EN 13041 [15] in order to avoid any change in volume (shrinkage/swelling) due to changes in water content. Knowing that the water content was expressed in % of the total volume, changes in total volume during irrigation events would make difficult to compare results between materials, and also results as a function of the initial MC. However, to minimize the effect of compaction on the interpretation of results, a same compaction rate was chosen for all raw materials and mixes. This rate was defined in order to maintain a same dry BD for a material, whatever its initial MC (40%, 50%, and 60% w/w), in order to be able to compare the water capture depending on these different initial MC.

Water retention curves, hydration efficiency tests, and contact angles measurements were carried out on relatively small and different volumes of substrates, equivalent to 250 cm^3, 200 cm^3, and approximately 5 cm^3, respectively. Due to these small quantities, the tested samples might not exactly correspond to the proportion defined for mixes, and could increase the variability of the results. To maximize the robustness of our results, we increased the number of replications compared to those previously defined in the literature (e.g., 6 replicates for retention curves instead of 3 prescribed in the NF EN 13041 [15] standard procedure, at least 8 and up to 16 replicates for hydration efficiency tests instead of 4 proposed by Fields et al. [8], and at least 6 replicates for both liquids (hexane and water) instead of 4 for contact angle measurements).

A low variability of results was observed during hydration efficiency tests for very hydrophilic (for wood fiber whatever its MC, and for peat-based mixes prepared at 60% w/w initial MC) or very hydrophobic (peat-based mixes equilibrated at a MC of 40% w/w) mixes. Conversely, a higher variability of results was often observed for peat-based mixes prepared at 50% MC (despite a number of 12 to 16 replicates). We hypothesize that the materials are in a transitional state between hydrophobicity and hydrophilicity, showing sometimes (but not always) preferential water flows in the substrate column.

4.2. Respective Weights of Peat vs. Wood Fiber Regarding the Ability to Rewet for Mixes

Water capture and container capacity measured on driest mixes did not respond to a proportional law calculated from their volumetric proportion in the mixes. Values measured for mixes were consistently lower than theorical proportional values calculated from those measured on both peat and wood fiber raw materials. For example, the water capture after a first irrigation (WC_1) was equal to 0.11 v/v for peat and 0.53 v/v for wood fiber; but the 80:20 P:WF mix only reached 0.13 v/v instead of the theorical value of 0.19 v/v. This suggested that hydrophobic properties of peat had a higher impact than hydrophilic properties of wood fiber in driest conditions. Conversely, the proportionality law occurred for wet materials, when they both were hydrophilic.

4.3. Wood Fiber and Other Peat Alternatives for Reducing Risks of Hydrophobicity—Consequences on Other Physical Properties

Our results demonstrated that the risks of acquiring hydrophobicity were reduced by an increasing proportion of wood fiber incorporated to peat-based mixes. However, wood fiber is not the only raw material used as substrate for which water retention properties are not deteriorated after drying. That is not the case for barks which present a similar behavior with peat, with a change from a hydrophilic to a hydrophobic character during drying. However, rockwool [8,22], perlite [8] and coir [6] also exhibit a high ability to rewet, and some substrates companies are particularly favoring for the last 5–10 years the use of coir for limiting risks of hydrophobicity in their peat-based recipes. Clay addition is sometimes practiced in peat-based substrates for reducing risks of hydrophobicity, but its incorporation largely affects their physical properties (water availability and air-filled porosity) of substrates by clogging part of porosity. A positive effect of wetting agent addition on the ability to rewet of peat was demonstrated by our works and previously by Michel [5], and its efficiency is higher and unparalleled in comparison with wood fiber (i.e., our results), but also with coir [6].

Peat is mainly used for its both high water retention and availability, and other materials such as wood fiber, barks, coir are usually added in order to improve the aeration properties of substrates and then to avoid risks of hypoxic conditions for the root system. Our results confirmed that wood fiber addition in peat-based mixes led to a decrease in both water retention properties and availability, but conversely, to an increase in aeration properties, that have to be considered for irrigation management. Thus, water availability became lower than 25% vol. from a proportion of 40% v/v wood fiber in the P:WF mix, and then did not meet the requirements defined by De Boodt and Verdonck [21]. The biological stability of wood fiber should also be considered, because it can change its physical properties over time. Previous works carried out on the wood fiber used in this study did not show any biological degradation. However, Domeño et al. [12] and Michel and Kerloch [23] reported an evolution over time of the physical properties of other wood fiber references, with a decrease of air-filled porosity and an increase of easily available water.

5. Conclusions

Wood fiber is a hydrophilic material, unlike peats which become more hydrophobic during drying. Wood fiber addition in peat-based mixes promoted their ability to rewet. However, a high proportion of wood fiber is required to counteract the influence of peat hydrophobicity and to recover water retention properties prior to drying. Thus, wood fiber allows to limit the risk of hydrophobicity of peat-based mixes, and its addition is beneficial, considering the needs of organic, renewable and inexpensive peat alternatives.

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